# Forecasting Development

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SUMMARY of TROPICAL CYCLONE ACTIVITY and FORECASTS in The 2000- 1 SOUTHERN HEMISPHERE SEASON

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## 1. INTRODUCTION

A summary of tropical cyclone activity in the southern hemisphere for the 2000-1 season is presented below together with an assessment of the performance of the Met Office global model in predicting the tracks of these tropical cyclones.

Tropical cyclones are experienced in the South Indian Ocean, tropical seas to the west, north and east of Australia and the western and central South Pacific Ocean. For the purpose of tropical cyclone verification the southern hemisphere is divided in to two basins; the South-West Indian (west of 90°E) and Australian (east of 90°E). Mean error statistics for each basin are presented together with a table of statistics for the whole southern hemisphere. The global model produces a 6-day forecast every 12 hours. Verification is performed at 24 hour intervals up to forecast time T+120.

The global model resolution in operation during the season was 0.83°x 0.55°x 30 levels. This is equivalent to a horizontal resolution of 93km x 62km at the equator. The tropical cyclone verification scheme identifies the centre of a tropical cyclone in the model by locating a local maximum of relative vorticity at 850hPa. A surface fitting technique is used to locate the centre accurately.

The terms used in the statistics tables are explained below :-

Possibly verified - No. of forecasts fulfilling requirements 1, 2 & 4 below.
Detection Rate - Percentage of possibly verified forecasts which also fulfil requirement 3 below.
Mean DX - Mean of positional errors in the East-West direction.
Mean DY - Mean of positional errors in the North-South direction.
Mean AT - Mean of positional errors in the Along Track direction.
Mean CT - Mean of positional errors in the Cross Track direction.
Skill - Percentage skill of model against CLIPER.
Mean DPE - Mean of direct positional errors.
All errors are measured in kilometres except where indicated.

(*) 1. Observed maximum wind at least 31 knots at the verifying time.
2. Forecast tropical cyclone centre equatorwards of 45 degrees.
3. Forecast tropical cyclone centre relative vorticity above a critical limit for verification ($0.7 \times 10^{-4}$ per second).
4. Observation within 6 hours of verifying time present for use in verification.

Forecast skill is defined as:-
(CLIPER DPE - Model DPE) / CLIPER DPE x 100%

Positive skill indicates the model forecast is better than CLIPER.
Negative skill indicates the CLIPER forecast is better than the model.

A diagrammatic explanation of other error statistics and their sign conventions can be found in Appendix A. Full details of the TC verification scheme can be found in ***NWP Gazette, Vol.1, No.2, December 1994.***

Advisory positions from RSMCs La Réunion and Nadi, Fiji, Bureau of Meteorology, Australia and JTWC Hawaii were used as verifying observations of storm location when track verification was carried out immediately after a storm had ended. Best track data from RSMCs La Réunion and Nadi, Fiji, Bureau of Meteorology, Australia and Met. Service, New Zealand have been obtained for this season's storms and the track forecasts verified again. Statistics for verification against best-track observations are presented in detail. Some statistics for verification against real-time observations are included for the purposes of a comparison and are denoted 'RT'. Some mean error statistics for last season are also included for the purposes of a comparison. Forecast tracks are only verified when a depression reaches tropical storm status.

## 2. TROPICAL CYCLONE ACTIVITY

| | SWI | AUS | TOTAL |
|---|---|---|---|
| Tropical Depressions (<34 knots) | 3 (1) | 1 (1) | 4 (2) |
| Tropical Storms (>34 knots, <64 knots) | 2 (4) | 8 (8) | 10 (12) |
| Hurricanes/typhoons (>64 knots) | 4 (5) | 4 (9) | 8 (14) |
| Total | 9 (10) | 13 (18) | 22 (28) |

Basin name abbreviations:- SWI = South-West Indian (west of 90°E)
AUS = Australian (east of 90°E)

The number in brackets indicates the figure for the 1999-2000 season.
N.B. 10-minute averaged wind speeds from RSMCs used when available. Data from JTWC (1-minute averaged) is only used when other data is unavailable and maximum wind speeds are scaled to make them equivalent to the RSMC 10-minute averages.

## 3. SUMMARY OF ALL SOUTHERN HEMISPHERE STORMS

### 3.1 South-West Indian Basin Storms

Table of Mean Error Statistics

| | T+0 | T+24 | T+48 | T+72 | T+96 | T+120 |
|---|---|---|---|---|---|---|
| Possibly Verified | 62 | 50 | 40 | 29 | 20 | 14 |
| Detection Rate (%) | 100 | 100 | 100 | 100 | 100 | 100 |
| Mean DX | 12 | -29 | -135 | -268 | -350 | -405 |
| Mean DY | 14 | 90 | 177 | 191 | 289 | 459 |
| Mean AT | 2 | 34 | 160 | 251 | 381 | 522 |
| Mean CT | 20 | 29 | 42 | -38 | -39 | 34 |
| Mean Skill (%) | ***** | 5 | 11 | -1 | ***** | ***** |
| 1999-2000 Skill (%) | ***** | 22 | 38 | 49 | ***** | ***** |
| Mean DPE | 44 | 161 | 291 | 380 | 545 | 703 |
| * 1999-2000 DPE | 43 | 130 | 246 | 351 | 443 | 509 |
| RT DPE # | 36 | 164 | 297 | 382 | 549 | 710 |

* DPE for all South-West Indian storms in 1999-2000 season
# DPE in 2000-1 calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Fig. 1.

Tropical cyclone activity was much lower than the last season; there were half as many analyses and only a quarter as many T+120 forecasts verified. Forecast errors were well above last season's values - particularly at T+96 and T+120. Skill scores were lower than they had been for several years. There was a fast bias in forecasts. Figs. 2 and 3 show forecast errors and skill scores for the last few seasons.

## 3.2 Australian Basin Storms

Table of Mean Error Statistics

| | T+0 | T+24 | T+48 | T+72 | T+96 | T+120 |
|---|---|---|---|---|---|---|
| Possibly Verified | 87 | 64 | 44 | 28 | 14 | 6 |
| Detection Rate (%) | 100 | 100 | 100 | 100 | 100 | 100 |
| Mean DX | 0 | -51 | -158 | -295 | -369 | -436 |
| Mean DY | 2 | 29 | -12 | -42 | -4 | -52 |
| Mean AT | -30 | -56 | -121 | -125 | -86 | -325 |
| Mean CT | -3 | -73 | -151 | -290 | -409 | -475 |
| Mean Skill (%) | ***** | 9 | 14 | 17 | ***** | ***** |
| 1999-2000 Skill (%) | ***** | 20 | 38 | 40 | ***** | ***** |
| Mean DPE | 64 | 185 | 315 | 447 | 543 | 722 |
| * 1999-2000 DPE | 41 | 136 | 235 | 342 | 468 | 610 |
| RT DPE # | 49 | 178 | 319 | 464 | 568 | 746 |

* DPE for all Australian storms in 1999-2000 season
# DPE in 2000-1 calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Figs. 4 and 5.

In common with the South-West Indian basin, activity in the Australian basin was low; there were 60% as many analyses as last season and just 20% of last season's T+120 forecasts (just 6 verifiable forecasts). Forecast errors were higher than in the previous three seasons and skill scores the lowest for many years. There was a slow and right-of-track bias in forecasts. Figs. 6 and 7 show forecast errors and skill scores for the last few seasons.

## 3.3 Combined Statistics for whole Southern Hemisphere

Table of Mean Error Statistics

| | T+0 | T+24 | T+48 | T+72 | T+96 | T+120 |
|---|---|---|---|---|---|---|
| Possibly Verified | 149 | 114 | 84 | 57 | 34 | 20 |
| Detection Rate (%) | 100 | 100 | 100 | 100 | 100 | 100 |
| Mean DX | 5 | -42 | -147 | -281 | -358 | -414 |
| Mean DY | 7 | 56 | 78 | 77 | 169 | 306 |
| Mean AT | -16 | -17 | 13 | 66 | 189 | 268 |
| Mean CT | 7 | -28 | -59 | -162 | -191 | -119 |
| Mean Skill (%) | ***** | 7 | 13 | 6 | ***** | ***** |
| 1999-2000 Skill (%) | ***** | 21 | 38 | 46 | ***** | ***** |
| Mean DPE | 56 | 174 | 304 | 413 | 544 | 709 |
| * 1999-2000 DPE | 42 | 133 | 241 | 348 | 452 | 543 |
| RT DPE # | 44 | 172 | 309 | 422 | 557 | 721 |

* DPE for all Southern hemisphere storms in 1999-2000 season
# DPE in 2000-1 calculated using real time observations as opposed to best track.

Comments :
Figs. 8 to 11 show forecast errors, skill scores, along and cross track errors over the last few seasons.

Tropical cyclone activity was low this season. Less than half as many forecasts were verified as in the previous season. Forecast errors were higher than the previous two seasons and similar to those in the 1997-8 season. Skill scores against CLIPER showed a marked drop and were the lowest for many years. There was a right-of-track bias in forecasts and a fast bias at longer forecast ranges. Forecast errors derived using best track data showed small differences to errors derived using real-time data.

After having shown an improving trend for many years, this season was marked by a worsening in forecast performance. Noel Davidson of the Australian Bureau of Meteorology advised that their model also produced poor results for the season. He suggested that a high proportion of the small

number of tropical cyclones which did develop fell into categories which are known to be relatively more difficult for numerical models to forecast:-
i) There were a number of weak and short-lived storms which developed around the coast and then made landfall.
ii) There were some sheared storms or storms which were marginal in terms of attaining tropical storm status.
iii) There were some storms which were located over low-data areas such as the central Indian and south-central Pacific Oceans.

The results for the 2001 northern hemisphere season (which followed this season) did not show a similar worsening in performance, so it is assumed at this stage that these poor results are not related to any fundamental forecast model deficiencies.

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## Further Tropical Cyclone Information

The Met Office pages on the World Wide Web contain information on tropical cyclone forecasting at the Met Office. Monthly bulletins of tropical cyclone activity and forecasts are held, together with observed and forecast track information of recent storms, track prediction error statistics, lists of names, images, movies and photographs and details of advances made in tropical cyclone track prediction at the Met Office. Real time tropical cyclone forecast guidance is also now available.

The Met Office web site is:- **http://www.metoffice.com**
Tropical Cyclone information can be found on the home page under the **"World Weather News"** heading.

Seasonal summaries of tropical cyclone activity and forecasts have been issued since the 1994-5 southern hemisphere season. To obtain these or any further information on tropical cyclone forecasting at the Met Office email **tropical_cyclones@metoffice.com**. Past seasonal reports can also be found on-line under the "Forecast Verification" section of the tropical cyclone pages on the Met Office web site.

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## Acknowledgements

CLIPER models for various basins were supplied by Mr.S.Lord, NMC, Washington, USA and Mr.C.Mauck, FNOC, Monterey, USA.
GrADS software used to produce track plotting charts was supplied by Mr.S.Lord and Dr.M.Fiorino.
Best track observations for the southern hemisphere were supplied by RSMC Météo-France, La Réunion, Bureau of Meteorology, Australia, RSMC Nadi, Fiji and Met. Service Ltd, New Zealand.


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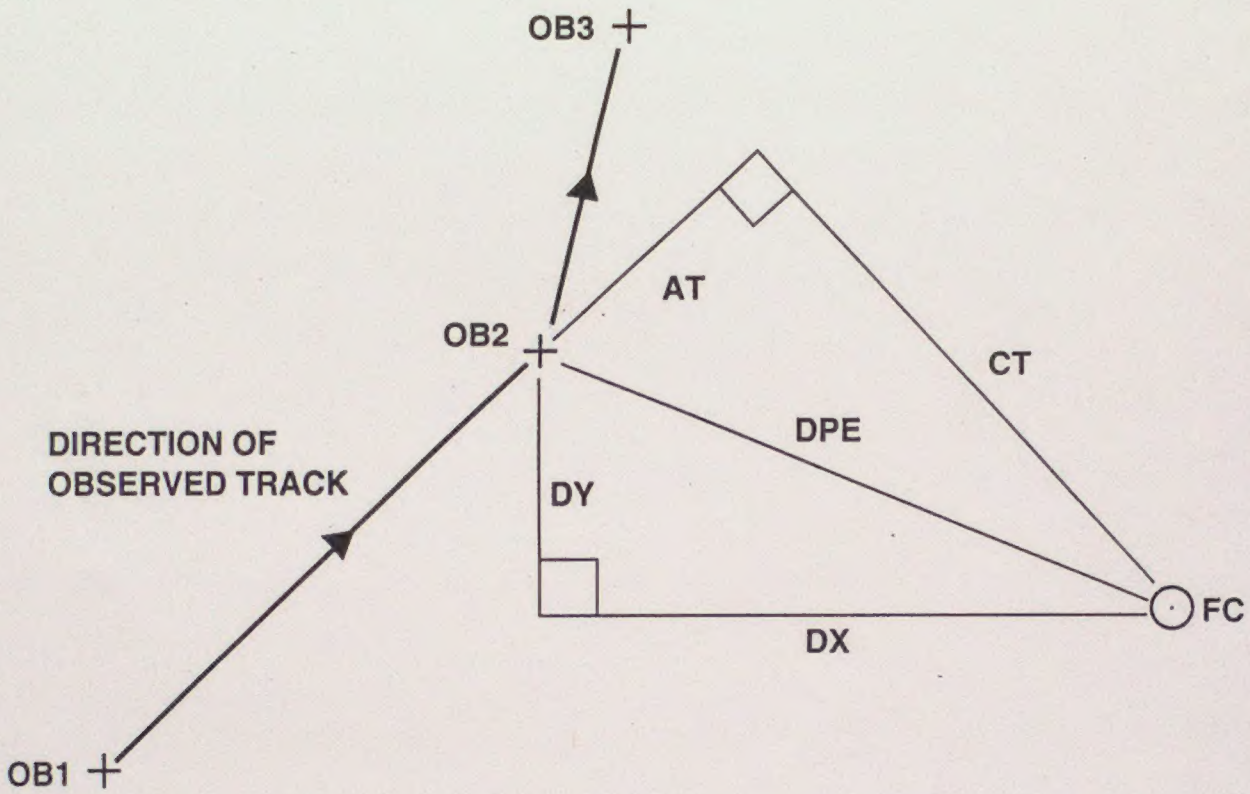
# APPENDIX A

## Diagrammatic Explanation of Forecast Errors




OB1-3 : Observed positions
FC : Forecast position verifying against observation OB2
DPE : Direct positional error
DX : Error in the East-West direction
DY : Error in the North-South direction
AT : Error in the Along Track direction
CT : Error in the Cross Track direction

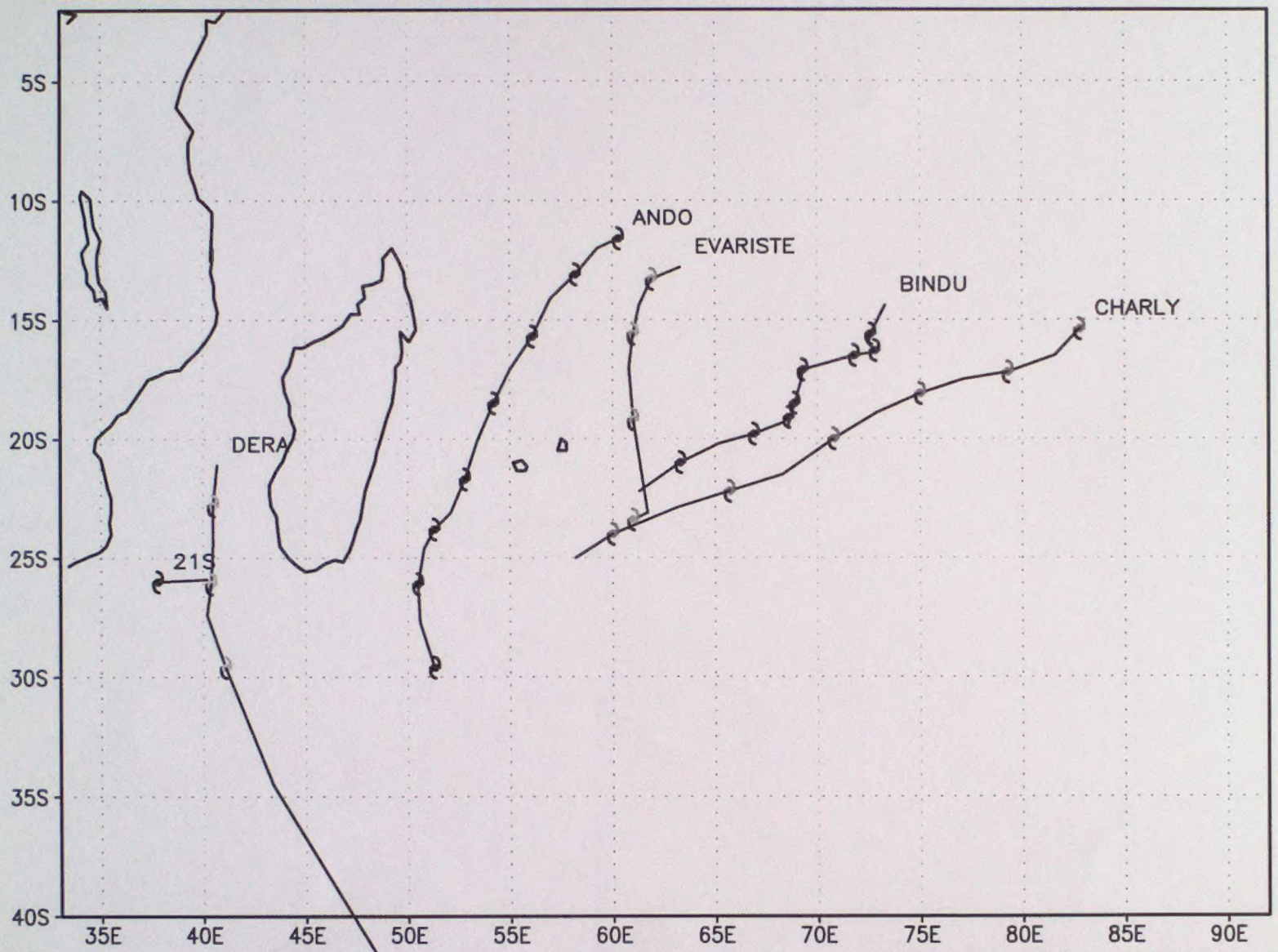
All errors are measured in kilometres

### Sign Conventions

DPE values are always positive.
DX errors are positive if the forecast position lies eastwards of the observed position.
DY errors are positive if the forecast position lies polewards of the observed position.
AT errors are positive if the forecast position lies ahead of the observed position along the tropical cyclone track.
CT errors are positive if the forecast position lies right of the observed track in the northern hemisphere and left of the observed track in the southern hemisphere.

Figure 1

OBSERVED TRACKS of TROPICAL CYCLONES in the SOUTH–WEST INDIAN BASIN




ANDO 20010103
21S 20010622
BINDU 20010109
CHARLY 20010120
DERA 20010310
EVARISTE 20010405

KEY to DATE of FIRST SYMBOL

24 HOURLY BEST TRACK OBSERVED POSITIONS

SYMBOLS REPRESENT 00Z POSITIONS

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Figure 2 South-West Indian Tropical Cyclone Forecast Positional Errors

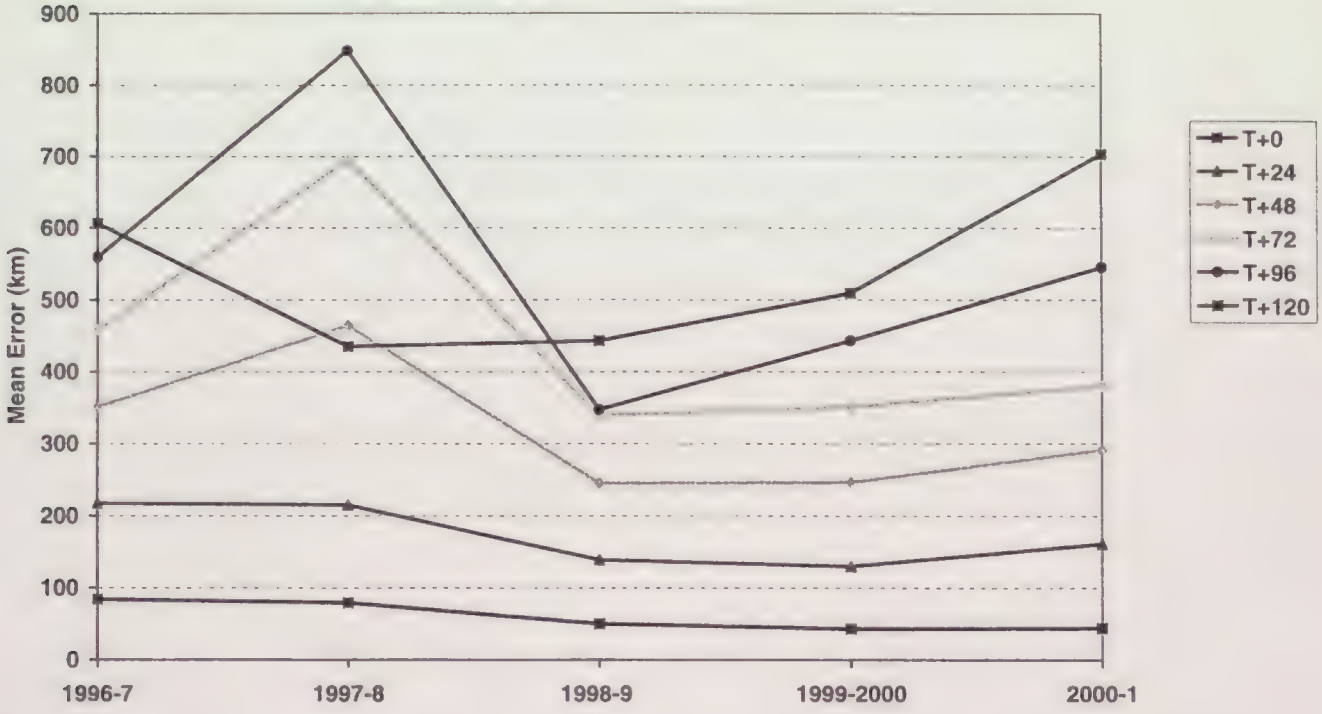
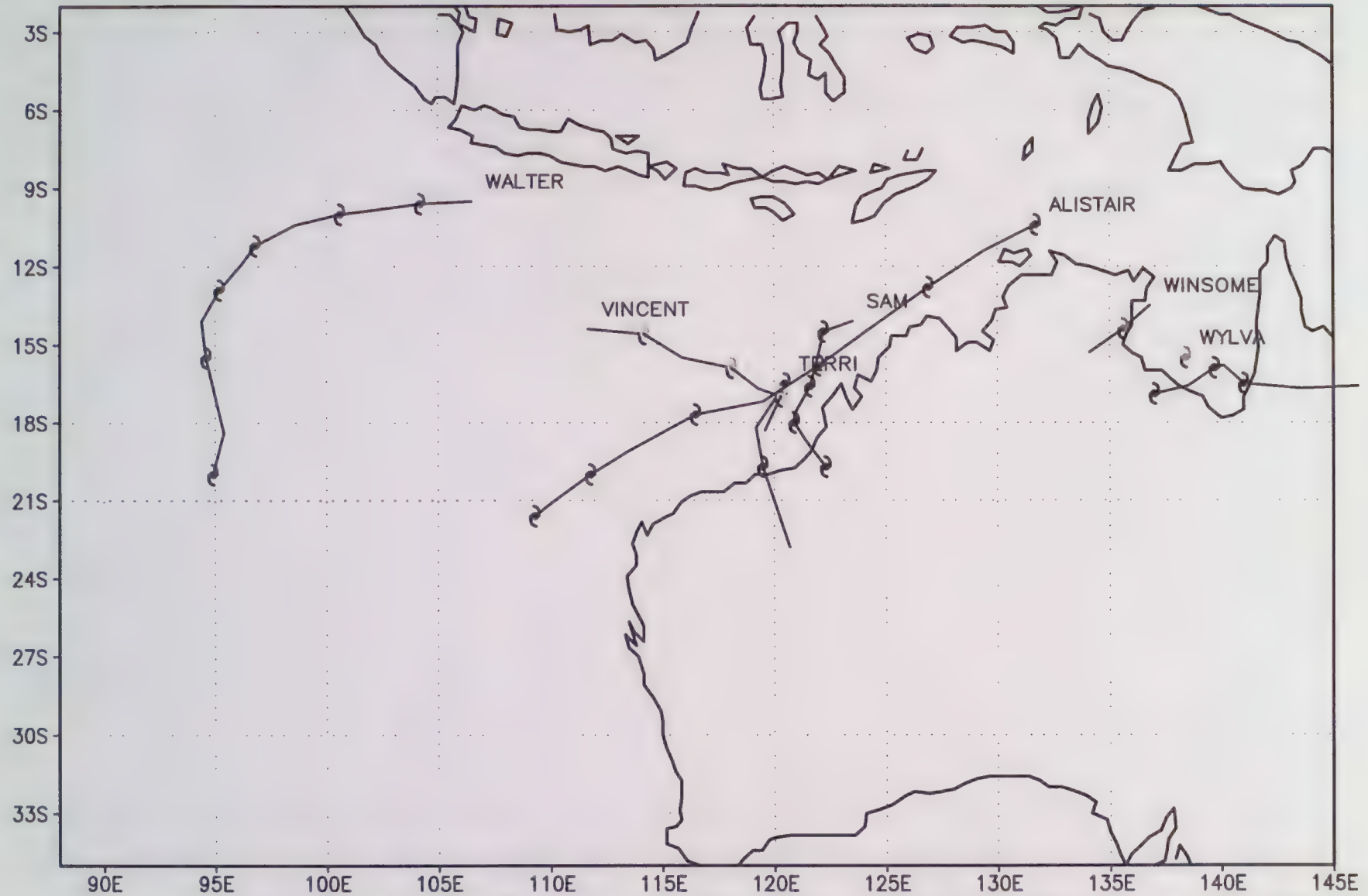



Figure 3 South-West Indian Tropical Cyclone Forecast Skill against CLIPER

**Figure 4**

OBSERVED TRACKS of TROPICAL CYCLONES in the WESTERN AUSTRALIAN BASIN




SAM 20001206 TERRI 20010130 WINSOME 20010211 VINCENT 20010213 WYLVA 20010216
ABIGAIL 20010224 WALTER 20010403 ALISTAIR 20010417

KEY to DATE of FIRST SYMBOL

24 HOURLY BEST TRACK OBSERVED POSITIONS

SYMBOLS REPRESENT 00Z POSITIONS

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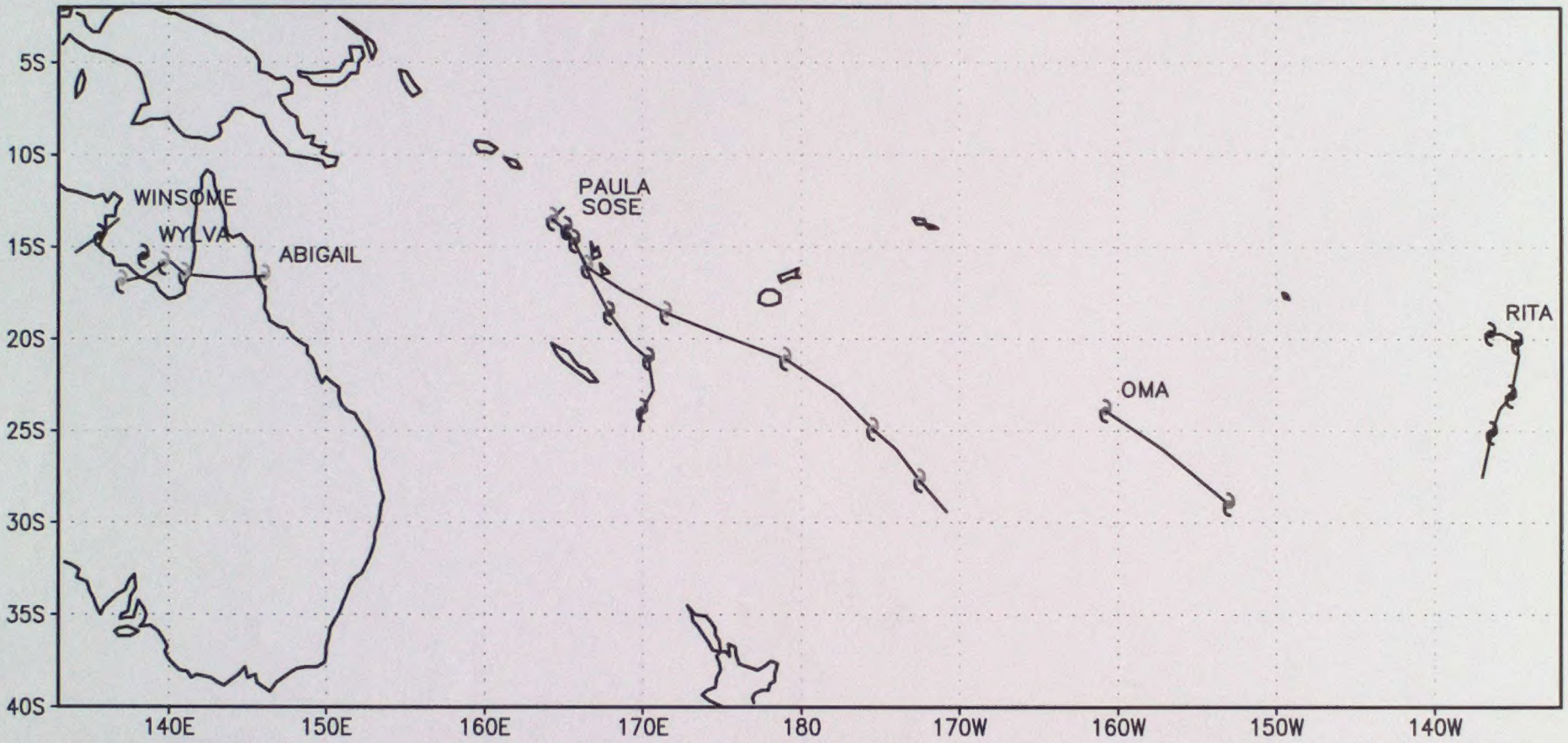
**Figure 5**

OBSERVED TRACKS of TROPICAL CYCLONES in the EASTERN AUSTRALIAN BASIN




WINSOME 20010211 WYLVA 20010216 OMA 20010221 ABIGAIL 20010224 PAULA 20010227
RITA 20010301 SOSE 20010406

KEY to DATE of FIRST SYMBOL

24 HOURLY BEST TRACK OBSERVED POSITIONS

SYMBOLS REPRESENT 00Z POSITIONS

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Figure 6 Australian Tropical Cyclone Forecast Positional Errors

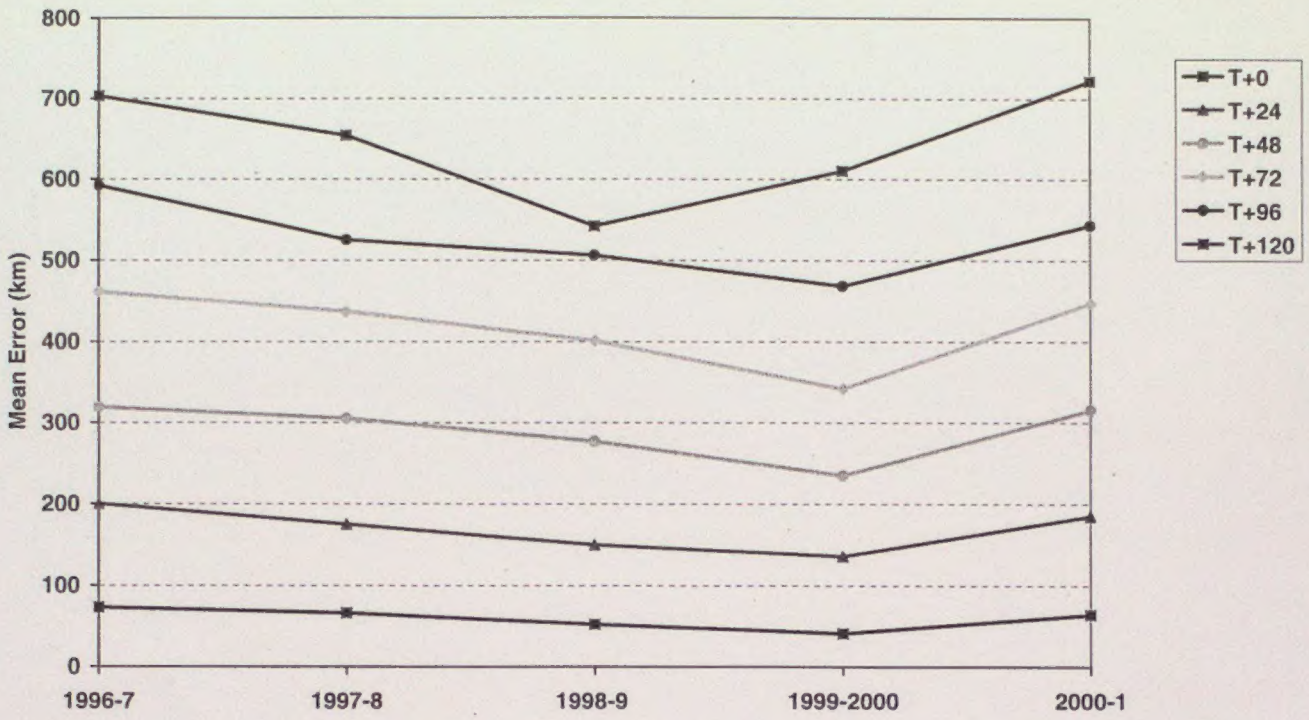



Figure 7 Australian Tropical Cyclone Forecast Skill against CLIPER

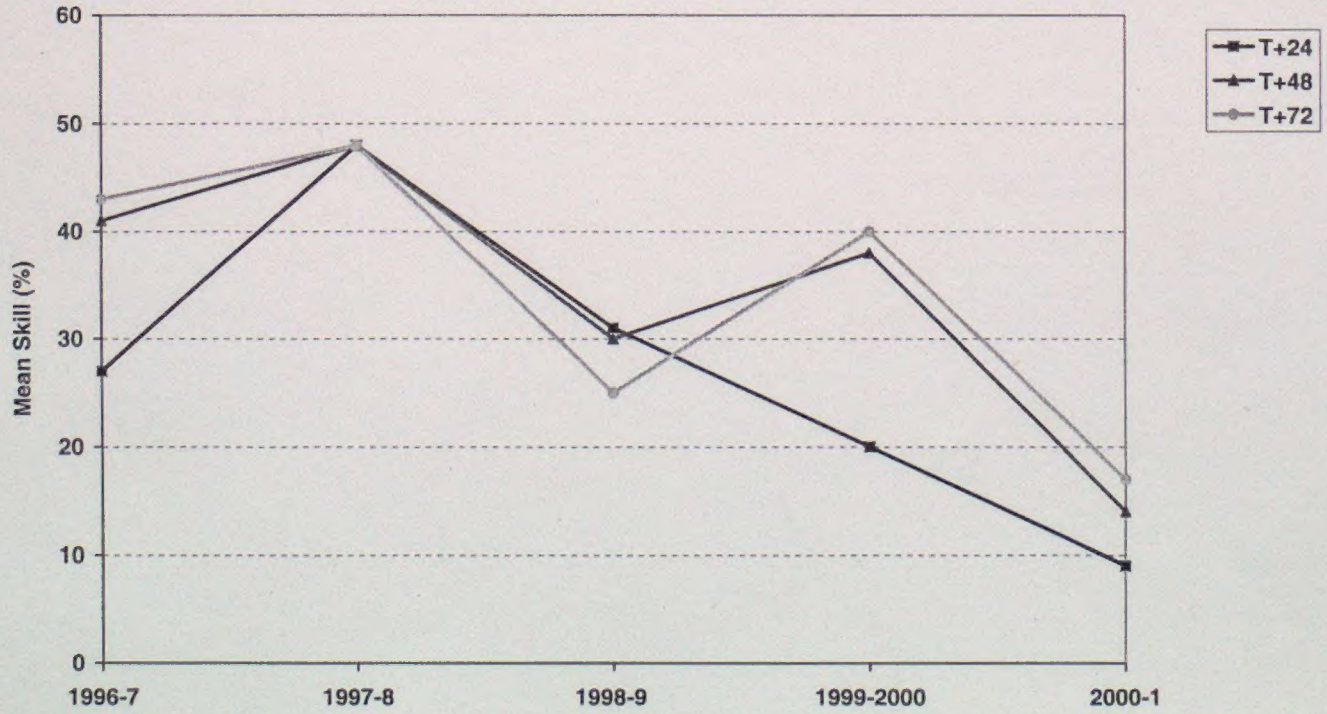


Figure 8 Southern Hemisphere Tropical Cyclone Forecast Positional Errors

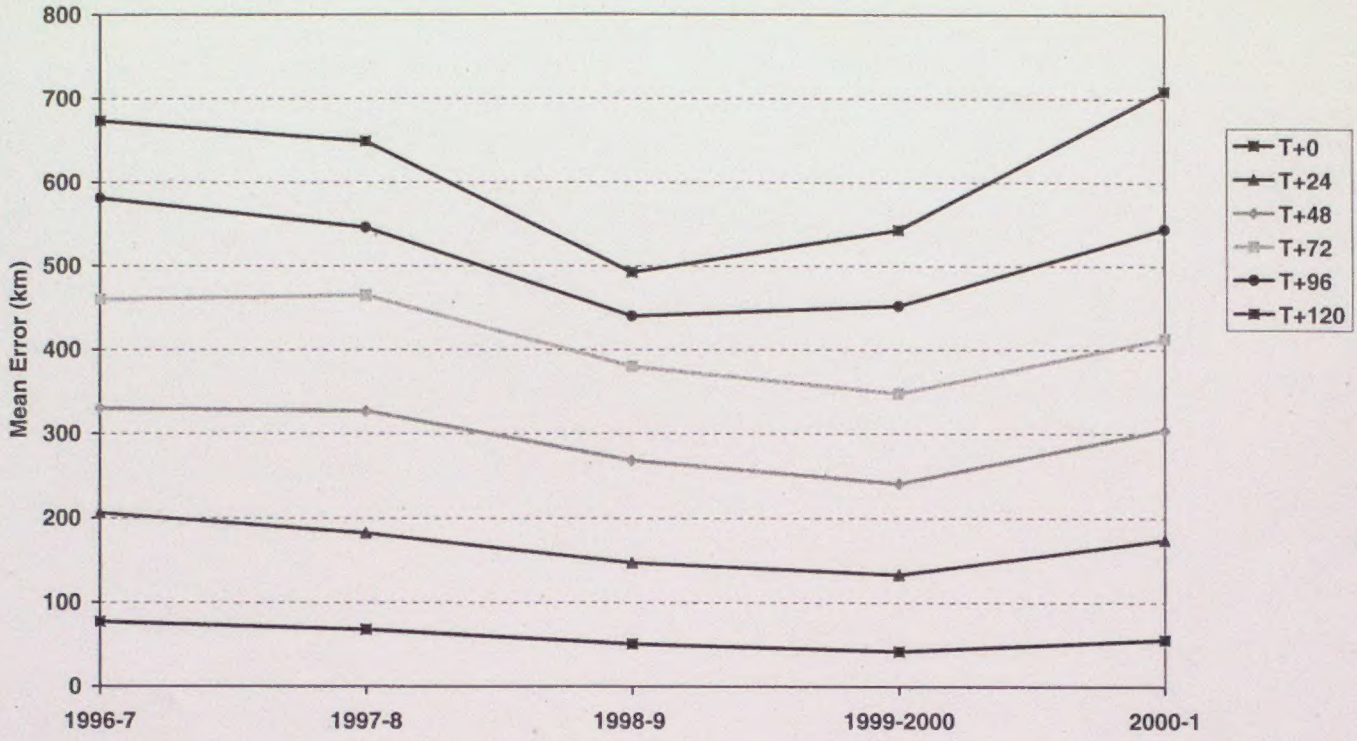



Figure 9 Southern Hemisphere Tropical Cyclone Forecast Skill against CLIPER

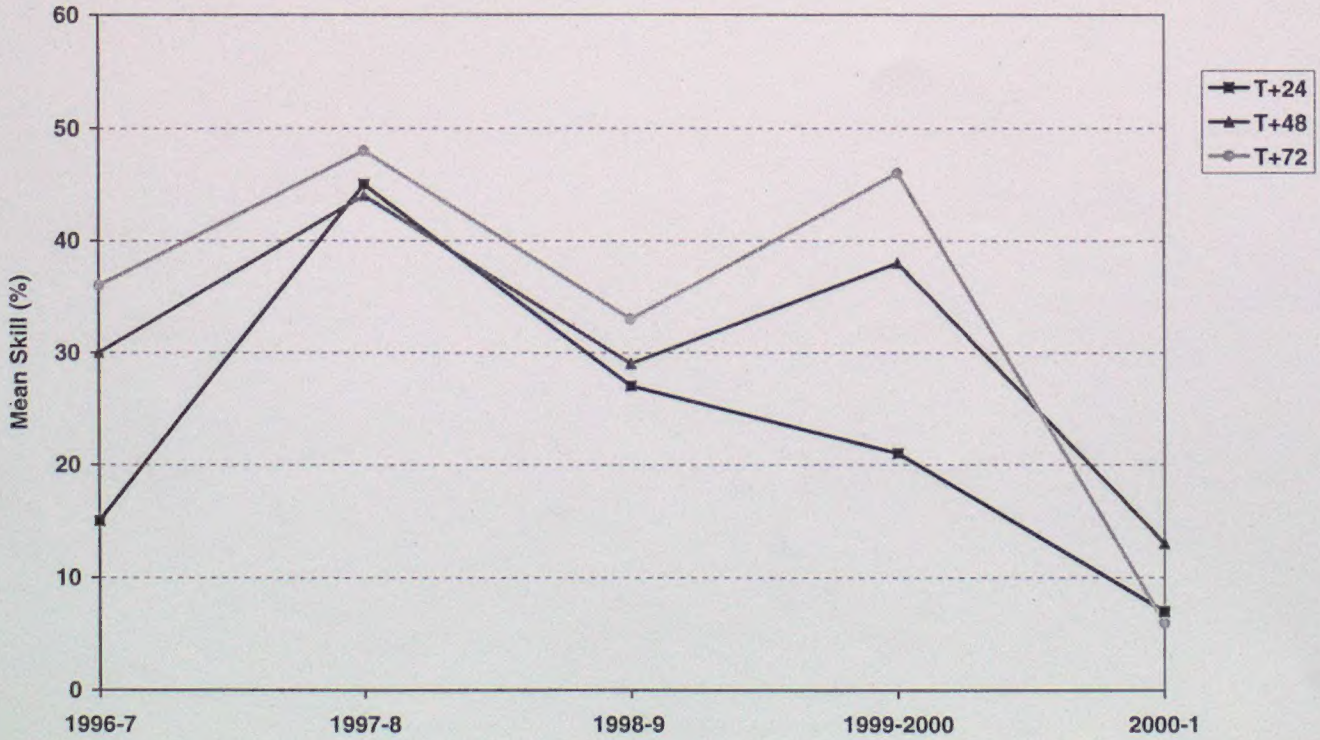
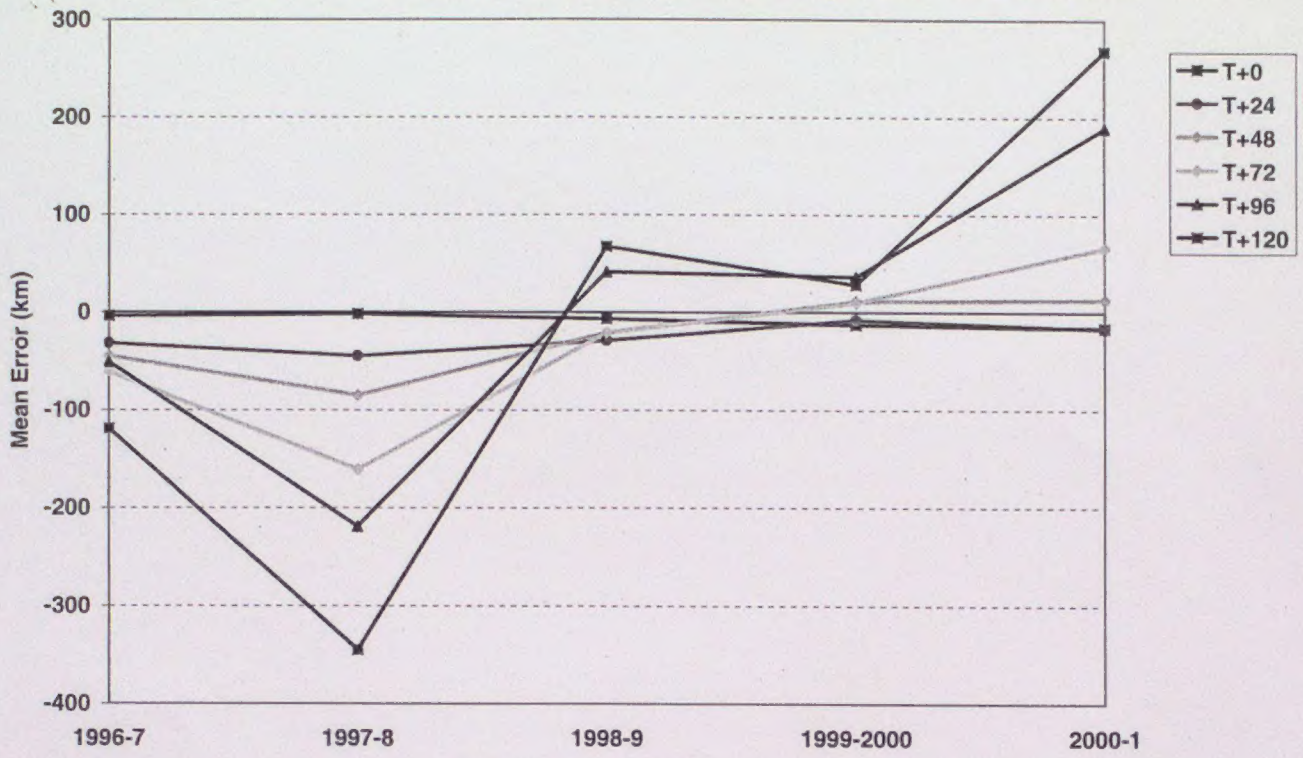


Figure 10 Southern Hemisphere Tropical Cyclone Along Track Forecast Errors



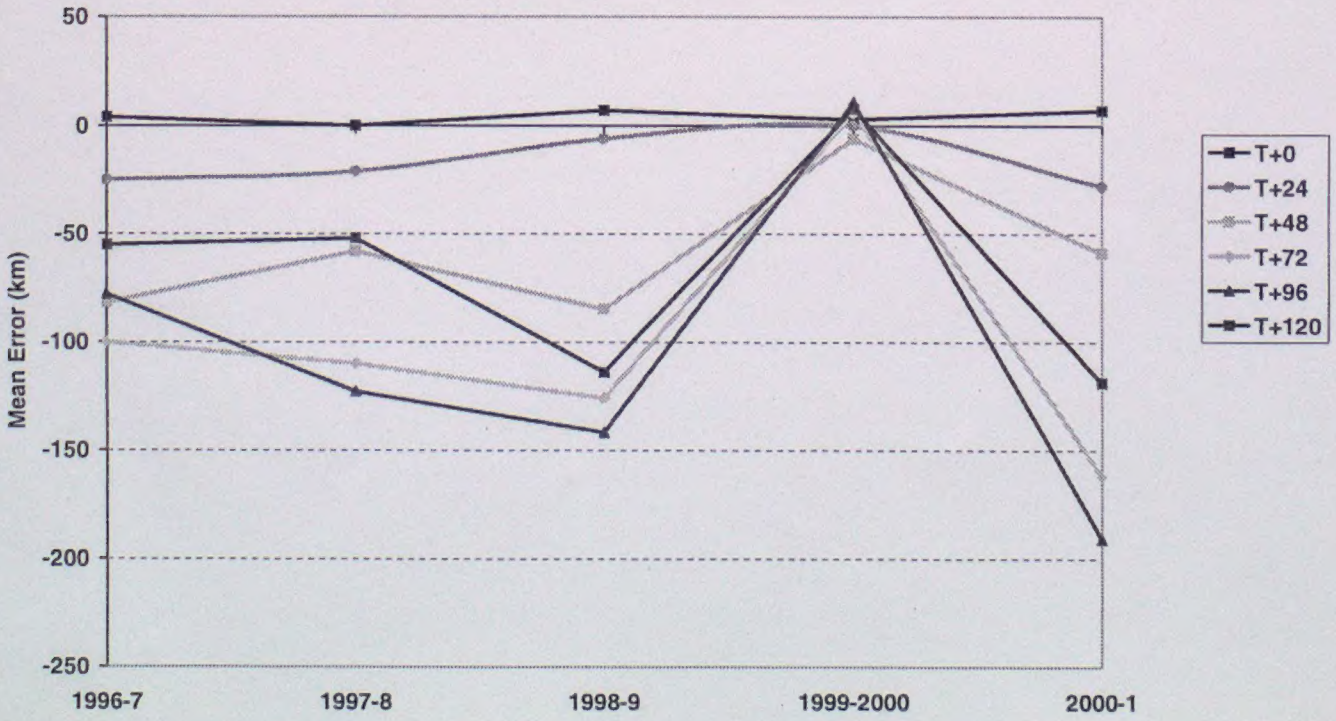


Figure 11 Southern Hemisphere Tropical Cyclone Cross Track Errors